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PHYTOTOXICOLOGY ASSESSMENT SURVEY INVESTIGATIONS ON CORNWALL ISLAND IN ONTARIO IN THE VICINITY OF THE REYNOLDS METALS COMPANY (RMC), MASSENA, NEW YORK 1987 AND 1988

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Report prepared by:
R. Emerson
Phytotoxicology Section
Air Resources Branch

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PHYTOTOXICOLOGY ASSESSMENT SURVEY INVESTIGATIONS ON CORNWALL ISLAND IN ONTARIO IN THE VICINITY OF THE REYNOLDS METALS COMPANY (RMC), MASSENA, NEW YORK - 1987 AND 1988

EXECUTIVE SUMMARY

A Federal-Provincial study with participation by several government agencies, including the Phytotoxicology Section, Ontario Ministry of the Environment, has been ongoing on Cornwall Island for several years. Cornwall Island is part of an Indian reservation (Mohawks of Awkwesasne). Phytotoxicology investigations, involving vegetation sampling and injury observations, to assess the impact of airborne fluoride emissions from the Reynolds Metals Company (RMC), Massena, New York, on vegetation on Cornwall Island, have been conducted during each growing season since 1969. The results of the most recent study findings in 1987 and 1988 are presented in this report.

In 1987 and 1988, the highest fluoride levels in vegetation on the island, as in previous years, were detected in the south shore bridge area (the immediate impact area), with levels decreasing sharply with increasing distance from this area. Fluoride concentrations in the impact area were about 10 times higher than normal and decreased to near normal with increasing distance to the far east end of the island. In 1987, fluoride levels in maple foliage collected in August and in forage collected monthly (May-October) increased slightly from 1986 levels; however, the more recent years' Manitoba maple foliage levels (1986 and 1987) and six-month forage fluoride means (1985-1987) were amongst the lowest to be detected since the survey began. As in most previous years, the MOE six-month forage criterion (35 ppm) was exceeded in 1987 only at the Bridge site in the south shore bridge area. The most adverse F-like injury to vegetation, as in prior years, was observed in the south shore immediate impact area. Injury to vegetation in 1987 was not markedly different from 1986, with there being a slight reduction overall in the degree and extent of foliar injury in 1987.

As a result of program constraints in 1988, vegetation surveys were conducted only in May and June. Soil for PCB and PAH analysis also was collected from Cornwall Island in May. 1988 fluoride levels in maple foliage collected in June and in forage collected in May and June were not markedly different from earlier years' results. Injury to vegetation in the south shore immediate impact area generally was reduced compared to the May-June observations of other recent years (1985-1987). The concentrations of PCBs and

PAHs found in surface soil (0-5 cm) on the island were all well below levels of concern relative to existing guidelines; however, in the case of some PAH compounds, evidence of a very minor deposition gradient was apparent.

Upon examination of the 1987 weather data for the Cornwall area and the 1987 air monitoring program results for Cornwall Island, it would appear that the slight overall increase in fluoride contamination of vegetation in 1987 was due to a combination of climatic conditions and increased fluoride emissions into the RMC survey area.

PHYTOTOXICOLOGY ASSESSMENT SURVEY INVESTIGATIONS ON CORNWALL ISLAND IN ONTARIO IN THE VICINITY OF THE REYNOLDS METALS COMPANY (RMC), MASSENA, NEW YORK - 1987 AND 1988

1. INTRODUCTION

A Federal-Provincial study with participation by Environment Canada, Agriculture Canada, National Health and Welfare, Indian and Northern Affairs and the Ontario Ministry of the Environment was established on Cornwall Island in 1975. Prior to this time, the Phytotoxicology Section had been conducting annual vegetation assessment programs and responding to complaints concerning the adverse effects of airborne fluoride emissions on vegetation and cattle since 1969. The source of the fluoride emissions was identified as the Reynolds Metals Co., located in Massena, New York. The study was broadened in 1975 in view of the transboundary nature of the emissions and their impact on the Awkwesasne Mohawk Indian Reserve on Cornwall Island.

The RMC vegetation assessment program has been conducted annually during the growing season without interruption since 1969. In 1988, because of budget constraints, Phytotoxicology surveys were performed on Cornwall Island only in May and June. The Phytotoxicology Section continued the RMC assessment survey on Cornwall Island in 1989.

During 1976 to 1986, the Phytotoxicology Section also conducted annual vegetation assessment surveys in the Long Sault area, downwind of the larger Aluminum Co. of America (ALCOA) plant located in Massena, N.Y., to the west of the RMC plant. In 1987, the Long Sault area portion of the survey was discontinued because of low fluoride levels and minimal concern for vegetation impacts.

The results for all earlier years' RMC and ALCOA vegetation assessment programs through to 1986 have been previously reported. This report presents the results of the most recent 1987 and 1988 study findings in the RMC survey area on Cornwall Island.

11. RMC ASSESSMENT PROGRAM - 1987 AND 1988

A. OBJECTIVE

The primary objective of the 1987 and 1988 RMC assessment programs was to determine the degree and extent of fluoride contamination and injury to vegetation and to compare these findings with previous years' results. An additional objective in 1988 was to assess potential soil accumulation of PCBs and PAHs on Cornwall Island as a result of emissions from RMC and other potential sources along the St. Lawrence River.

B. SAMPLE COLLECTION FOR CHEMICAL ANALYSIS

Samples Collected During 1987

In 1987, contrary to previous years, tree foliage and forage samples were collected only on Cornwall Island, and the September sampling of pine needles for fluoride analysis was discontinued. These cut-backs were made to reduce the number of samples/analyses.

Maple Foliage

Manitoba maple foliage was collected in mid-August from exposed middle branches only at the ten regular stations (Sites 1, 2, 3, 6, 7, 8, 9, 20, 21, 33) sampled in previous years on Cornwall Island. Sampling was discontinued at the seven regular Manitoba sites (Sites 4, 5, 12, 13, 14, 17, 19) on the Ontario mainland. In 1987, Manitoba maple foliage also was collected from Site 1 in May, June and July, from Site 33 in June and July, and from the Lillian Point property in August (see Figures 1 and 2).

In addition, exposed red maple foliage was sampled from the south shore area woodlots (west and east of bridge) in June and August, as well as from the west bridge woodlot in May. The maple sampled from the west bridge woodlot was situated about 100 m west of Manitoba maple Site 21, while the tree from the east bridge woodlot was situated about 50 m east of Manitoba maple Site 1. Also, red maple foliage was collected from exposed branches on the N. Point property in June, July and August, from the Lillian Point property in August, and from the west tip of the island in June (see Figures 1 & 2).

Forage

In 1987, forage sampling was discontinued on the Ontario mainland (Farlinger, McGee, Lunenburg Sites) as well as at the Pearce, Lazore, Seymour and West Tip forage sites on the island. At the remaining eight regular forage sites on the island, forage was sampled each month during May through October (see Figure 1). Prior to 1978, forage sampling was performed only in June, July and August.

Samples Collected During 1988

Maple Foliage and Forage

As in previous years, red maple foliage was sampled in mid-June from the two south shore area woodlots (west and east of bridge) and from the N. Point property. In addition, forage was collected in May and June at the eight sites which were sampled on the island in 1987.

Soil

In May 1988, surface soil (0-5 cm) for PCB and PAH analysis was collected at the same eight forage sites, as well as at the former A. Lazore forage site near the east end of the island. Duplicate samples, with each consisting of a composite of about ten soil cores, were collected at each site with an Oakfield soil sampler using standard organic sampling procedures. The soil cores were sealed in amber glass jars with a foil lined lid. Latex gloves were worn and the sampling equipment was cleaned between sites using the MOE washing procedure for organic sampling. The sampling was conducted following the release of US data which indicated that PCBs had been discovered in soil on the RMC property. Analysis of the soil for PAHs was included because aluminum smelters are a potential source of PAH emissions.

C. SAMPLE COLLECTION FOR HISTOLOGICAL EXAMINATION

A full description of the foliage samples collected and submitted in both years for histological analysis is shown in Table 9.

D. SAMPLE SUBMISSION FOR CHEMICAL ANALYSIS

Vegetation

All foliage and forage samples for chemical analysis were processed in the Phytotoxicology processing laboratory and submitted for analysis on a dry weight basis to the Inorganic Trace Contaminant Section, Laboratory Services Branch, MOE.

The regular Manitoba maple foliage collection (August 1987) was processed on a washed and unwashed basis, as were the red maple foliage samples collected in June 1988. The other vegetation samples collected in both years, including all forage collections, were processed as unwashed samples. All vegetation samples were analyzed for fluoride. In addition, the following samples collected in 1987 were analyzed for aluminum and sodium: the unwashed samples of the regular Manitoba maple collection in August, the foliage previously collected from Manitoba maple Sites 1 and 33, and the red maple foliage collected from the west bridge woodlot in May and from the N. Point property in July.

Soil

The two sets of soil samples collected in May 1988 were submitted (as collected) to the MOE Organic Trace Contaminants Section, Laboratory Services Branch. One set of soil samples was analyzed for PAH's (polycyclic aromatic hydrocarbons) while the second set was analyzed for PCB's (polychlorinated biphenyls).

E. VISUAL INJURY ASSESSMENT PROGRAM

In 1987 and 1988 (May-June), as in previous years, native vegetation (wild grape, cherry, maple, etc.) in the RMC survey area was examined for foliar fluoride injury during May to August, with the pine needle injury assessment in 1987 being conducted through to mid-September. In 1987, injury assessments also were performed on cultivated grape, vegetable crops and gladiolus plantings on Cornwall Island.

111. RESULTS OF VEGETATION ASSESSMENT PROGRAM IN 1987

A. Analytical Results for Maple Foliage

Fluoride

In 1987, as in previous years, the highest foliar fluoride levels were detected at Manitoba maple collection Site 1 in the south shore bridge area (east of bridge) to the immediate northeast of RMC (Tables 1 and 2). The fluoride results for the regular Manitoba maple collection in August, as in previous years, displayed a decreasing pattern with increasing distance from the south shore bridge area (Table 1).

Manitoba maple foliage also was collected at Site 1 in May, June and July, with the fluoride level found in May (213 ppm) being the highest to be detected in vegetation on Cornwall Island during 1987. At Site 1, foliar levels of fluoride generally decreased through to August. In contrast, foliage fluoride levels at the slightly more remote A. Boots (Site 33) and N. Point properties increased slightly during June to August (Table 2).

Fluoride levels in red maple foliage samples collected during May to August from the south shore woodlots (west and east of bridge) also were elevated, with the highest levels (59 and 109 ppm respectively) being detected in August (Table 3). The fluoride levels for all red maple sites sampled through to June, 1987 in the immediate area of RMC were particularly elevated in relation to the corresponding 7 ppm foliar level found in June at the more remote west tip of the island (Table 2).

Fluoride levels in the unwashed Manitoba and red maple foliage samples collected in August (1987), overall, were found to be slightly increased from 1986 levels. However, the fluoride results of the regular (August) Manitoba foliage collection in 1986 and 1987 generally were amongst the lowest to be detected since the survey began.

The average contribution of particulate surface contamination to the total fluoride level in Manitoba maple foliage at most sites in August also was generally increased relative to 1986 particulate removal levels (Table 4). However, the degree of particulate surface contamination washed from the foliage sites in August 1987 was similar to earlier years (1982-1985) results.

Aluminum And Sodium

The aluminum and sodium results for the unwashed regular Manitoba collection in August (1987) are compared to earlier years' (1982-86) data in Table 5. In contrast with previous years, the highest mean aluminum level in August was detected at Site 2 (185 ppm) to the north-northeast of RMC, as opposed to Site 1 (northeast). As with fluoride, the aluminum levels found in 1987 (August) were slightly increased from 1986 levels but, for the most part, were generally lower than previous years' (1983-85) results. As in earlier years, the highest mean sodium level in August was detected at Site 1 (105 ppm) in the south shore immediate impact area. August 1987 sodium levels in the survey area generally were lower than 1986 levels and were amongst the lowest to be detected since the survey began.

Manitoba maple foliage for aluminum and sodium analysis also was collected in 1987 at Site 1 in May, June and July, as well as at more remote Site 33 in June and July. As with fluoride, the aluminum and sodium levels detected in May (Al 290 ppm; Na 390 ppm) were the highest detected on the island in 1987. At Manitoba maple Site 33, situated slightly more remote to the northeast of RMC, generally lower levels of aluminum (58-84 ppm) and sodium (81-103 ppm) were detected during June through August (Table 2).

Table 2 also shows that levels of aluminum and sodium in the red maple foliage sampled from the west bridge woodlot in May (Al 100 ppm; Na 75 ppm), and from the N. Point property in July (Al 52 ppm; Na 39), also were reduced from levels found in the south shore bridge area (Site 1).

B. Comparison of Unwashed Maple Foliage Results with Phytotoxicology Section Guidelines

Fluoride

On Cornwall Island, during 1987, maple foliage was sampled from two sites in May, six sites in June, three sites in July and fifteen sites in August. The foliar fluoride level detected at nearly all collection sites each month, with exception of one site in both June and August, exceeded the 15 ppm Phytotoxicology Section Upper Limit of Normal (ULN) rural guideline for unwashed foliage. In the immediate impact area, fluoride levels in maple foliage (August) were about 10 times higher than the rural ULN.

The ULN guideline represents the expected maximum concentration in foliage from rural areas of Ontario not subject to the influence of point sources of emissions.

Aluminum and Sodium

As in previous years, even the highest foliar aluminum level (290 ppm at Site 1) found in the RMC survey area was below the Phytotoxicology Section 500 ppm guideline for unwashed foliage.

The 50 ppm rural sodium guideline was exceeded at all maple sites where foliage for sodium analysis was sampled during May to August, with exception of one site in July and two sites in August. Of the ten annually-sampled Manitoba maple sites in August, eight sites had a foliar sodium level greater than the 50 ppm rural guideline, as compared to seven sites in 1986, eight sites in 1985 and nine sites in 1984.

C. Analytical Results for Forage

As in earlier years, the highest monthly fluoride levels in unwashed forage were detected at the Bridge site in the south shore immediate impact area, just east of the International Bridge. As with maple foliage, fluoride levels in forage decreased with distance from this area (Tables 6 and 7).

Comparison of the six-month (May-October) growing season fluoride means for 1978 to 1987 (Table 6), and of the three month (June-August) means since 1969 (Table 7), revealed that fluoride levels at most forage sites were slightly increased in 1987 compared to 1986 and 1985 levels. In spite of the slight increase in 1987, the fluoride levels in the forage samples collected from Cornwall Island in recent years (1985 - 1987) were amongst the lowest to be detected since the RMC survey began.

D. Comparison of Forage Results with MOE Ontario Forage Criteria

As in most previous years, the MOE's six-month growing season fluoride criterion for forage (35 ppm) was exceeded at the Bridge site (37 ppm), which was the closest forage site to the northeast of RMC. This was the only exceedance of the one (80 ppm), two (60 ppm) and six (35 ppm) consecutive month MOE forage criteria in 1987. These values compare with no exceedances in 1986, a single exceedance in 1985, eleven in 1984, four in 1983 and three in 1982.

E. Injury Assessment Findings

Wild Grape

By August, the most severe F-like injury on wild grape, as in previous years, was observed at well exposed sites within 10 m of the river (south shore) to the neighbouring west and east of the International Bridge. The most adversely affected sites exhibited trace (>0-1%) to moderate (11-35%) injury, with most affected leaves exhibiting only trace (>0-1%) to light (2-10%) injury. All other injured grape plants in the south shore (immediate impact) area exhibited only trace injury, with the injury observed throughout this area being very light overall as in 1986.

In August, the zone of trace (>0-1%) injury extended slightly beyond the immediate impact area through to the vicinity of the N. Point forage site to the northeast (Figure 1). F-like injury to wild grape plants on Cornwall Island generally was less extensive in 1987 compared to 1986 and 1985.

Staghorn Sumach

Peculiar foliar injury (terminal, marginal and/or interveinal brown-blackish necrosis), similar to that described in previous reports, was observed on young and/or mature compound leaves on Staghorn sumach primarily in the south shore bridge area (immediate impact area) through to August. Injured thickets in this area exhibited pronounced injury on young compound leaves in May and June. The foliar injury observed during May through August ranged from trace (>0-1%) to severe (>35%), with the greatest overall injury, moderate (11-35%), being observed on sumachs growing close to the river to the neighbouring west of the bridge. In August, the injury was confined primarily to mature or older foliage, with younger foliage on the majority of thickets being green and healthy, and most affected thickets throughout the immediate impact area exhibited only trace (>0-1%) to light (2-10%) injury overall. The observations to the slightly more remote northeast also revealed trace to light injury on mature sumach foliage on the Lilian Point property (Figure 2).

The absence of injury on more remote thickets coupled with the histological analysis results in May, 1987 (Table 9) would indicate that RMC emissions had contributed to the observed sumach injury in the immediate area of RMC.

The severity of injury to sumach thickets throughout the immediate impact area was fairly similar to that observed in 1986, with there being a possible slight improvement in 1987.

Cherry And Plum Trees

F-like reddish foliar injury was most pronounced on cherry trees (black, choke and pin cherries) in the south shore immediate impact area (west and east of bridge) early in the growing season. In June, the most severe injury was observed on a mature choke cherry to the neighbouring east of the bridge and on a young black cherry growing on the riverbank to the neighbouring west of the bridge. These trees displayed several leaves with trace (>0-1%) to moderate (11-35%) necrosis, but the injury at both sites was light (2-10%) overall. All other affected cherry trees examined throughout this area in June exhibited only a few leaves with reddish tip and/or marginal necrosis and had trace (>0-1%) injury overall. Histological analysis confirmed that the injury to the above-noted choke cherry tree in June was typical of fluoride (Table 9).

In August, cherry trees examined throughout the south shore immediate impact area exhibited either no F-like necrosis or only trace (>0-1%) injury on a few leaves. The only exception was the injured black cherry tree (west of the bridge) which had several leaves with trace to severe (>35%) injury but only light (2-10%) injury overall. However, as a young choke cherry to the neighbouring west was healthy, and as other cherry trees in the immediate impact area were in generally good condition, it is doubtful that the observed injury on this black cherry was solely due to RMC emissions.

The foliar examinations in August also revealed trace (>0-1%) F-like injury to a pin cherry on the Lillian Point property to the slightly more remote northeast, as well as injury to the black cherry trees on the nearby A. Boots property (Figure 2). The black cherry trees on the Boots property during June through August displayed several leaves with a spotty disease-like injury pattern as in previous years.

In addition, during June through August, trace (>0-1%) to very light (2-10%) F-like foliar injury was observed on the plum trees the writer planted in the immediate impact area to the west of the bridge in 1984. Also, during June to August, the mature plum tree on the more remote N. Point property displayed primarily light (2-10%) to moderate (11-35%) foliar injury, with most leaves in August, as in previous years, displaying dark brown necrosis and injury abscising from the foliage. However, in light of the area observations, it is questionable whether fluoride emissions were the primary cause. Other plum trees that were examined on the island, including the mature trees on the A. Boots property, did not display any peculiar foliar injury.

The severity of foliar injury observed on cherry and plum trees in the south shore immediate impact area in 1987 was fairly similar to 1986.

Manitoba Maple

In May, 1987 greyish-black marginal injury was pronounced on younger foliage at Manitoba maple Site 1, in the south shore immediate impact area (Figure 1), and the foliar fluoride level (213 ppm) at this site was elevated. However, histological analysis (Table 9) did not confirm that RMC fluoride emissions were the primary cause of the injury. Fluoride injury on Manitoba foliage is typically a reddish to orange-tan colour.

In June, the overall condition of Manitoba maple at Site 1 was much improved, with much of the earlier injury having abscised, and some mature leaves as well as a few younger leaves exhibited a very light degree of F-like marginal necrosis. By July, several Manitoba maples across the island exhibited at least some F-like injury.

In August, F-like injury (orange-tan necrosis and/or chlorosis), of varying severity, was observed on several Manitoba maples across Cornwall Island as well as at remote sites on the Ontario mainland, with younger foliage generally being the most adversely affected (a similar injury pattern was observed on Manitoba maple throughout the Cornwall area in 1985). In the general area of RMC in August, as in July, the most severe foliar injury was not observed in the south shore immediate impact area where expected, but rather on the slightly more remote Lillian Point property to the northeast. The more adversely affected maples on the L. Point property were judged to exhibit borderline moderate (11-35 %) to severe (>35 %) injury overall, and histological analysis (Table 9) implicated fluoride emissions as being a contributor.

However, as the observations during the latter part of the summer revealed pronounced F-like foliar injury on Manitoba maples at distances well beyond possible effects of RMC emissions, Manitoba maples in 1987 could not be regarded as reliable indicators of fluoride injury. Nonetheless, as the F levels in Manitoba maple foliage samples collected during May to August from the immediate impact area (Site 1) and from L. Point property were well above normal, and as other sensitive vegetation (wild grape, cherry, red maple, red pine) in the area was injured, fluoride emissions likely contributed to at least some (but not all) of the foliar injury observed on Manitoba maples to the neighbouring northeast of RMC during 1987. The histological analysis results lend further support to this conclusion.

Red and Silver Maple

During June through August 1987, foliar injury (tip and/or marginal reddish-brown to tan and/or blackish necrosis) was observed on exposed red maples growing in the east bridge woodlot (east of Manitoba maple Site 1), as well as on the slightly more remote Lillian Point, N. Point and A. Boots properties to the northeast of RMC. Blackish and/or dark brown marginal and/or tip injury also was observed on exposed red maple foliage in the south shore west bridge woodlot (west of Manitoba maple Site 21) through to August (Figure 1 and 2).

In August, the most severe injury to red maple foliage was observed in the east bridge woodlot where the injury severity, ranging from trace (>0-1%) to severe (>35%), was judged to be borderline light (2-10%) to moderate (11-35%) overall. At the other locations noted above, the overall injury was either trace (>0-1%) or light (2-10%). Histological analysis of the injured foliage from the east woodlot, where the highest fluoride level of 109 ppm was detected in red maple foliage, confirmed the presence of injury typical of fluoride (Table 9). The July histological analysis results for the Lillian Point property would further suggest that fluoride emissions had contributed to the observed foliar injury on red maples to the neighbouring northeast of RMC.

However, as brownish-blackish foliar injury also was observed through to August at red maple sites considered to be too remote to be affected by RMC emissions, it is doubtful that the injury to red maples in the area of RMC was entirely related to emissions of fluoride from RMC. The histology results also would support this conclusion.

Silver maples growing on and near the A. Boots property, slightly north of the immediate impact area, also were injured by August. However, in August, variable degrees of blackish tip and/or marginal foliar injury were observed on several silver maple trees across Cornwall Island, which further implicates a natural causal agent as contributing to the observed injury on maples in the survey area.

Trembling Aspen and Serviceberry

In May and June 1987, foliage on trembling aspens in the south shore immediate impact area (west and east of bridge) exhibited distinct tip, marginal and/or interveinal blackish necrosis. In August, trembling aspens throughout this area displayed several leaves with chlorosis and/or blackish-brown necrosis and cupping, with the necrosis at most sites being either light (2-10%) or moderate (11-35%) overall. It was suspected that RMC emissions may have contributed as remote aspens examined were in a generally healthy condition. However, histological analysis did not confirm that fluoride emissions were the primary cause. Only in 1985 did histological analysis reveal typical fluoride injury on trembling aspen foliage in the area of RMC.

Foliar injury (dark reddish-brown to blackish marginal and/or tip necrosis) also was observed through to August on the small serviceberry tree growing beside the river to the west of the bridge. As in 1986, the severity of reddish-brown foliar marginal necrosis displayed by this tree was light (2-10%) overall in August. Nearby, F-like injury was observed on sensitive wild grape plants, but also nearby were a young Manitoba maple tree and a young choke cherry tree, both of which were in good condition in August. Wild grape and Manitoba maple are listed as sensitive to fluoride, while serviceberry and choke cherry are listed as intermediate in sensitivity. Therefore, it is questionable whether fluoride emissions were the primary cause of the observed foliar injury to the serviceberry tree.

Pine Needle Assessment

Current year's needles were examined on pines across Cornwall Island during July through September. In recent years (1984-1987), F-like reddish necrosis has been observed on red pine needles only on the N. Point property to the neighbouring northeast of the south shore immediate impact area. On the N. Point property, in 1987, only some needles on a single red pine exhibited F-like injury (histological analysis confirmed that the observed injury was typical of fluoride), with the injury being trace (>0-1%) overall. The observations in 1986 revealed injury to current year's needles on several red pines, with the injury being light (2-10%) overall

No obvious F-like injury was observed on other pines examined in 1987, including the Eastern white pines growing in the south shore area woodlot to the west and east of the bridge.

Cultivated Grape

As in 1986, cultivated grape plants were examined monthly (June-August) on the A. Boots property which neighboured the south shore bridge area, and in August on the more remote Earny Benedict (centre of island) and A. Lazore (east end of island) properties (see Figure 2).

On the Boots property, in July and August, only a few mature leaves exhibited reddish F-like (tip and/or marginal) necrosis, with the overall injury being trace (>0-1%) and inconsequential. F-like foliar injury was not observed at the more remote grape sites examined in August. The injury severity observed in the Boots vineyard was similar to that observed in 1986.

Garden Crop Assessment

In mid-July, foliar assessments were performed on island garden crops, including sweet corn plantings in the area of RMC. None of the examined vegetable crops exhibited any foliar injury which was considered to be unusual.

Gladiolus Assessment

In 1987, gladiolus plantings were observed (in the area of RMC) only on the N. Point and Lloyd Point properties which were located slightly northeast of the south shore immediate impact area. The glads were examined on the N. Point property monthly (June-August) and on the L. Point property in mid-July.

In July, gladiolus plants at both sites exhibited some leaves with F-like reddish-tan tip injury and/or marginal necrosis of trace (>0-1%) severity overall. In August, the glads on the N. Point property exhibited slightly more severe injury, with some leaves having reddish-tan necrosis extending down both margins. The severity of foliar injury to the glad plants on the N. Point property in August was very light (<5%) overall.

F. Histological Analysis Results

The foliage samples collected in 1987 for histological analysis and the results are summarized in Table 9. In 1987, foliar fluoride injury was confirmed on choke cherry, Manitoba maple, red maple, staghorn sumach and red pine to the neighbouring northeast of RMC. The histological results, supported by the observations, indicated that a natural causal agent also was contributing to the observed foliar injury on maples in the immediate area of RMC.

IV. RESULTS OF ASSESSMENT SURVEYS IN 1988

A. Vegetation Fluoride Results and Comparison with Guidelines

Maple Foliage

The fluoride results for the red maple foliage samples collected in June 1988 from the south shore area woodlots (west and east of bridge), and from the N. Point property, are compared to previous years' June results in Table 3. By mid-June, the three foliage collection sites had a fluoride level greater than the Phytotoxicology Section 15 ppm rural guideline, with the highest fluoride levels (77 and 79 ppm) being detected in the east bridge woodlot and on the N. Point property to the northeast (downwind) of RMC.

Table 3 shows that the foliar fluoride level found in the east bridge woodlot generally was lower than in earlier years (1984, 1985, 1987), and that the fluoride levels for the west bridge woodlot (42 ppm) and the N. Point property were generally increased but were not markedly different from previous year's (1984 through 1987) June levels.

Forage Results

In 1988, forage from the RMC survey area was collected only in May and June as survey activities ceased after June. As in previous years, the highest monthly fluoride levels (29 & 52 ppm) were detected at the Bridge Site in the south shore immediate impact area (Table 8), with levels sharply decreasing with increasing distance from this area. However, the fluoride levels which were detected each month at the Bridge site did not exceed either the single month (80 ppm) or two month (mean-60 ppm) Ontario forage criteria.

The May and June results for each site have been averaged and the two-month means are compared to corresponding earlier years' (1978-1987) results in Table 8. The forage fluoride means for 1988 (May and June) were found to be slightly increased from 1987 and 1986 means, but were not markedly different from most of the earlier data since 1978.

B. Soil PCB and PAH Results

None of the soil samples collected from the nine forage sites on Cornwall Island in May 1988 were found to contain any PCBs at the analytical detection limit of 0.02 ppm (Table 10). This detection limit is well below the 0.5 ppm PCB guideline which has been recently recommended for agricultural soil, including home gardens, by a federal/provincial working group. Table 10 shows that all but four of the soil PAH concentrations were elevated at the Bridge site compared to more remote sites. In several cases soil concentrations of the various PAHs displayed an apparent decrease with increasing distance to the NE of RMC. However, in May, the ground at the Bridge Site was blackened or charred because of prior grass burning and, as vegetation burning could also be a source of PAHs, it is possible that the recent burning contributed to soil PAH levels detected at the Bridge site.

An Inter-Ministry Committee on Clean-up Criteria has recommended site-specific clean-up guidelines for 10 of the 16 PAH compounds shown in Table 10. In comparing the Cornwall Island levels with these guidelines, it is apparent that the island levels are at worst (Bridge site) lower than the respective guidelines by factors of 3 (for benzo (a) pyrene) to more than 100 (for naphthalene). Therefore, it would appear that even the most elevated PAH concentrations at the Bridge site are well below levels of concern, based on the present state of knowledge.

C. Injury Assessment Findings and Histological Results

In May and June 1988, vegetation which had been injured in previous years was examined in the south shore immediate impact area, as was vegetation at more remote sites in June. By June, in the south shore immediate impact area, F-like injury was present on some cherry (choke, pin) and plum trees, but the injury generally was confined to only a few leaves and was very light in severity. Histological analysis confirmed that the foliar injury observed in June on choke cherry in the south shore area just east of the bridge was typical of fluoride (Table 9).

The serviceberry injured in previous years to the west of the bridge also exhibited some reddish marginal injury, with the injury overall being very light (2-10%). Also, some staghorn sumachs in the south shore immediate impact area exhibited some leaves with spotty blackish marginal necrosis through to June, but histological analysis did not indicate that fluoride emissions were the primary cause. Compared to earlier years (1985-1987), the severity of foliar injury on sumachs throughout the immediate impact area was markedly reduced in 1988.

Red maples examined in June in the south shore woodlots (west and east of bridge) exhibited foliar injury more typical of weather stress (Late Spring Leaf Scorch, drought) than fluoride. An exposed mature red maple on the slightly more remote N. Point property also was examined in June, but this maple did not display any obvious marginal necrosis. The fact that the fluoride levels in the injured foliage (unwashed-77 ppm; washed-39 ppm) from the east bridge woodlot and in the non-injured foliage (unwashed-79 ppm; washed 44 ppm) from the N. Point property were similar, further implies that the foliar injury observed in the south shore woodlot was more likely weather related than due to fluoride emissions.

The observations in the south shore immediate impact area in May and June revealed no unusual foliar injury on wild grape plants, trembling aspen or on Manitoba maple. Manitoba maple Site 1 to the immediate northeast of RMC had a bushy, healthy crown of foliage in June.

Compared to other recent years' (1984-1987) May and June observations, the overall condition of vegetation in the south shore immediate impact area was much improved in 1988. Vegetation examined in June at more remote island locations did not display any injury which could be directly attributed to RMC emissions. Cultivated grape plants and garden crops were not examined on the A. Boots property or at other locations on Cornwall Island in 1988.

V. RESULTS OF ENVIRONMENT CANADA AIR MONITORING PROGRAM AND METEOROLOGICAL ASPECTS FOR 1987

Since 1976, ambient fluoride has been monitored annually during the growing season (April through October) at Station B on the Elijah Benedict farm, near the centre of Cornwall Island. In 1987 and 1988, ambient fluoride also was monitored at new Station D, which was established in 1987 on the Martin property in the south shore area just east of the bridge. In 1987 and 1988, a wind recorder also was maintained at Station D during mid-April through mid-October.

Below is a brief discussion of the Cornwall Island air monitoring results for 1987, which were received by the Phytotoxicology Section, MOE, in February 1989. The Environment Canada Cornwall Island ambient fluoride and wind data report for 1988 was not available when this report was written.

The historical (1976-1987) summary of the 24-hour average fluoride levels for Station B (Benedict farm, near centre of island) revealed that ambient levels of particulate and gaseous fluoride on Cornwall Island were markedly increased in 1987 compared to 1986 levels and to the record low levels of 1985. The six month

(April through October) 24 hour average gaseous level (0.39 micrograms/cubic meter) at Station B was the second highest level to be recorded at this station since air monitoring began in 1976.

In 1987, the highest 24 hour average particulate and gaseous fluoride levels were detected at Station D (established in 1987) in the south shore bridge area to the immediate northeast of RMC. The 24 hour average fluoride levels (particulate 0.28; gaseous 0.55 micrograms/cubic meter) for the six months of air monitoring at this station were the highest to be recorded during the growing season to date on Cornwall Island.

Environment Canada found in 1987 that wind direction during the April through October air monitoring period was predominantly from the west (20.9%) as in 1986 (26%), with the secondary and tertiary winds being from the northwest (16.9%) and southwest (15.1%), as compared to the east (17.9%) and northwest (12%) in 1986.

The percentage of south, southwest and west winds, and frequency and amount of rainfall recorded at the Ontario Hydro climatic station, Cornwall, during May through August are compared to earlier years' data in Table 11.

These wind data further confirm that the percentage of winds blowing from RMC into the survey area increased slightly in 1987 from 1986 levels. This increase was most pronounced in July. Table 11 also shows that there was a decrease in the total amount and frequency of rainfall received in 1987 between May 1 and August 18 (date of regular Manitoba maple foliage collection) compared to 1986 which was one of the wettest years on record.

The fact that there was a significant increase in ambient fluoride levels at island Station B to the northeast in 1987 and that, in previous years (e.g. 1983, 1984), Environment Canada found lower ambient fluoride levels coupled with a significantly higher percentage of SW winds (30.7%) than in 1987 (15.1%), suggests that fluoride emissions into the survey area increased in 1987 compared to some other years. However, the 1987 vegetation data, contrary to the 1987 ambient fluoride results, did not reflect any major change in air quality from 1986.

Some discrepancies between the air monitoring and vegetation data have also been found in other years (e.g. 1980 and 1981). In vegetation, fluorides are adsorbed and/or absorbed by the cuticle of the leaf and/or enter plant leaves directly via the stomates. As fluoride entry into foliage is influenced by a number of uncontrollable variables (wind direction and speed, rainfall, temperature, sunlight, soil moisture, soil fertility, age of leaf, species etc.), most of which are weather related, an automated sequential air monitor is certainly a more efficient receptor of fluorides than vegetation and this may account for the lack of a stronger relationship between the air monitoring and vegetation data in 1987.

V1. SUMMARY OF RMC SURVEY FINDINGS - 1987 AND 1988

A. 1987 Findings and Conclusions

The main findings of the 1987 survey on Cornwall Island can be summarized as follows:

1) RMC emissions during 1987 resulted in elevated levels of fluoride, aluminum and sodium in vegetation particularly in the south shore bridge area (northeast of RMC), with the highest levels being found in May at Manitoba maple Site 1 just east of the bridge. Fluoride levels in vegetation, as in previous years, displayed a decreasing pattern with increasing distance from RMC.

2) Fluoride levels in maple foliage (August) and in forage (May-October) in 1987 were slightly increased overall compared to 1986 levels. However, the fluoride levels found in recent years in Manitoba maple foliage collected in August (1986 and 1987) and in forage collected during May to October (1985-1987) were amongst the lowest to be detected on Cornwall Island since the survey began. As with fluoride, foliar aluminum levels in August were slightly increased in 1987 but were lower than previous years' (1983 -1985) levels. In contrast, foliar sodium levels in August were reduced from 1986 levels and were amongst the lowest ever detected.

3) The slight increase in foliar contamination from 1986 to 1987 resulted in a slight increase overall in the number of exceedances of the Phytotoxicology foliage guidelines. In forage, only the MOE 35 ppm six month growing season criterion was exceeded at the Bridge site. This criterion has been exceeded at the Bridge site each year since sampling on a six-month basis began (in 1978) with exception of 1986.

4) F-like injury was observed on deciduous vegetation similarly injured in 1986, with the most adverse effects, as in previous years, being generally confined to the south shore immediate

impact area of Cornwall Island. The foliar examinations did not reveal any major change in injury from 1986, with the degree and extent of F-like injury to deciduous vegetation being slightly reduced overall in 1987.

5) On conifers, F-like injury, as in 1986, was observed only on red pine needles on the Noah Point property (slightly northeast of south shore bridge area), with the number of pine trees affected being reduced in 1987.

In conclusion, fluoride contamination of vegetation on Cornwall Island in 1987 was slightly increased from 1986, but the more recent years' Manitoba maple foliage August levels (1986 and 1987) and six-month forage fluoride means (1985-1987) were amongst the lowest to be detected since the survey began. The foliage examinations also did not reflect any dramatic change in injury from 1986, with there being a slight reduction in the degree and extent of injury overall in 1987. As in previous years, the highest degree of foliar contamination and injury to vegetation was confined to the south shore bridge area (immediate impact area) of the island, to the neighbouring northeast of RMC.

On the basis of the Environment Canada air monitoring results and the associated meteorological data previously discussed, it would appear that the slight overall increase in fluoride contamination of vegetation in 1987 was related to a combination of climatic conditions and increased fluoride emissions into the survey area.

B. 1988 Findings and Conclusions

The main findings of the 1988 (May-June) survey are as follows:

1) Foliar fluoride levels detected in June near the island's south shore to the neighbouring north to northeast of RMC were elevated relative to the Phytotoxicology (15 & 35 ppm) foliage guidelines. The fluoride levels detected at 2 of the 3 sites sampled in June were slightly increased from 1987 levels, but the 1988 levels were not markedly different from other recent years' (1984-1987) results.

2) May and June fluoride levels in forage, as in previous years, were the highest in the south shore bridge area (Bridge site) and sharply decreased with increasing distance from this area. The May-June fluoride means overall were found to be slightly increased from the 1987 and

1986 two-month means, but were not markedly different from most of the earlier years' May and June data since 1978.

3) Some vegetation in the south shore bridge area exhibited foliar F-like injury by June; however, vegetation throughout this area remained in generally good condition through to June and injury overall was less severe than in 1987.

4) Soil concentrations of PCBs and PAHs at the forage sites sampled in May on Cornwall Island all were found to be well below levels of concern relative to existing guidelines; however, in the case of some PAH compounds, trend of decreasing levels was found with increasing distance from the RMC site.

TABLE 1

Fluoride Results for Unwashed Manitoba Maple Foliage
Collected on Cornwall Island During Mid to Late August: 1972-1987

Site No.	Site Location	Approximate Distance (Km) and Direction from RMC	**Average Unwashed Fluoride Concentration (ppm - dry wt.)															
			1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982[a]	1983[a]	1984[a]	1985[a]	1986[a]	1987[a]
1	S Shore - E of Bridge	1.5 NE	451	597	516	1,171	550	750	193	197	143	192	380	293	389	337	159	149
33	A. Boots	1.9 NE	-	-	-	-	-	-	-	-	-	-	-	123	117	71	49	48
3	P. Hopps	3.1 NE	-	-	-	-	122	217	32	57	60	86	70	97	113	92	48	59
6	E. Benedict	4.1 NE	317	244	98	235	114	56	22	32	23	71	28	48	57	48	25	44
7	A. Lazore	6.8 NE	90	-	79	100	116	37	23	21	15	64	15	37	39	33	18	24
21	S Shore - W of Bridge	1.3 NNE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69	74
2	Customs	2.0 NNE	-	-	-	-	123	138	17	31	10	50	25	57	63	50	27	48
8	J. Thompson	1.9 N	30	-	76	60	29	45	15	21	8	18	12	27	23	32	19	18
9	R. Seymour	2.5 N	-	-	-	66	31	14	7	15	5	26	18	19	14	22	17	14
20	E End of Island	6.1 ENE	-	-	-	-	-	-	6	15	3	29	17	31	41	26	19	22

[a] Ion selective electrode method used; prior to 1982 the Alkali fusion method was used.

** Averages for 1975-79; 1983-86 are based on triplicate collections. A single composite sample was collected at each site in 1980-1982 and prior to 1975. Duplicate samples were collected in 1987.

TABLE 2

Fluoride, Sodium and Aluminum Levels Detected at Additional Maple Foliage Sites Sampled During May through August 1988

General Location	Elements	Foliar Concentration - ppm, dry wt.			
		May 14[1]	June 17[2]	July 13[2]	August 18[2]
			Manitoba Maple		
S Shore - Bridge Area (Site 1)	F	213	209	164	149
	Al	290	130	145	101
	Na	390	300	200	105
A. Boots (Site 33)	F		33	62	48
	Al		58	84	72
	Na		97	103	81
L. Point	F				97[1]
			Red Maple		
W Tip of Island	F		7[1]		
W Bridge Woodlot	F	52	25		59
	Al	100			
	Na	75			
E Bridge Woodlot	F		107		109
Lillian Point	F				48[1]
Noah Point	F		55	56	81
	Al			52	
	Na			39	

[1] Fluoride level in a single sample

[2] Mean fluoride level based on duplicate sample results

TABLE 3

Red Maple Foliage Fluoride Levels Detected in June and August 1987 and in June 1988 Compared to Corresponding Earlier Years' Results

Location	Fluoride Concentration (ppm - dry wt.)									
	August Results					June Results				
	1987[2]	1986[2]	1985[2]	1984[3]	1982[1]	1988[1]	1987[2]	1986[2]	1985[2]	1984[2]
	South Shore Area Woodlots									
W of Bridge	59	37	22	134	-	42(20)*	25	20	18	69
E of Bridge	109	43	139	278	99	77(39)	107	29	104	130
	Slightly Northeast									
Noah Point	81	42	88	172	-	79(44)	55	26	-	63**

[1] Fluoride level in a single sample

[2] Mean of duplicate sample results

[3] Mean of triplicate sample results

* Fluoride level in washed foliage - all other results represent unwashed levels

** Fluoride level found on Lillian Point property just south of N. Point.

TABLE 4

Comparison of Particulate Removal Values for the Manitoba Maple Foliage Samples Collected on Cornwall Island in August 1982 through 1987, Based on the Unwashed (NW) and Washed (W) Fluoride Results

Site No.	General Location	Distance (Km) and Direction from RMC	Per cent (%) Decrease in F Concentration (Particulate Removal) of Foliage due to Washing[a]					
			1982	1983	1984	1985	1986	1987
1	S Shore - E of Bridge	1.5 NE	53	41	22	32	47	57
33	A. Boots	1.9 NE	-	50	32	17	18	52
3	P. Hopps	3.1 NE	31	30	6	10	25	51
6	E. Benedict	4.1 NE	29	48	33	33	0	32
7	A. Lazore	6.8 NE	0	59	36	18	0	17
21	S Shore - W of Bridge	1.3 NNE	-	-	-	-	19	20
2	Customs Area	2.0 NNE	48	79	8	36	26	35
8	J. Thompson	1.9 N	33	48	22	34	5	17
9	R. Seymour	2.5 N	17	32	14	27	18	14
20	E End of Island	6.1 ENE	29	55	32	31	21	32
Mean ± standard deviation			40 ±18	49 ±13	24 ±9	32 ±11	12 ±13	33 ±15

[a] Calculated from the following formula: $\frac{NW - W}{NW} \times 100$

TABLE 5

Levels of Aluminum and Sodium in Unwashed Maple Foliage Collected on Cornwall Island in August of 1982 through 1987

Site No.	General Location	Distance (Km) and Direction from RMC	Concentration - parts per million - dry weight											
			Aluminum						Sodium					
			1982[1]	1983[3]	1984[3]	1985[3]	1986[3]	1987[2]	1982[1]	1983[3]	1984[3]	1985[3]	1986[3]	1987[2]
1	S Shore - E of Bridge	1.5 NE	174	181	193	217	127	101	520	373	480	420	137	105
33	A. Boots	1.9 NE	-	131	130	62	45	72	-	253	287	160	110	81
3	P. Hopps	3.1 NE	74	99	107	84	47	62	245	157	223	143	84	88
6	E. Benedict	4.1 NE	32	79	69	78	22	67	112	107	109	100	65	61
7	A. Lazore	6.8 NE	70	110	103	137	41	77	48	67	95	89	48	36
21	S Shore - W of Bridge	1.3 NNE	-	-	-	-	29	76	-	-	-	-	117	99
2	Customs	2.0 NNE	96	128	83	90	47	185	132	70	85	81	69	91
8	J. Thompson	1.9 N	51	96	57	115	35	67	85	77	68	64	39	57
9	R. Seymour	2.5 N	49	66	26	58	28	58	125	43	61	34	35	36
20	E End of Island	6.1 ENE	80	110	81	74	27	51	53	77	99	105	74	52

[1] Fluoride concentration in a single sample

[2] Mean of duplicate sample results

[3] Mean of triplicate sample results

TABLE 6

Monthly Fluoride Levels Detected in Unwashed Forage Collected on Cornwall Island during 1987 and Corresponding Seasonal (May - Oct.) Means for 1978-1987

Site Location (in order of increasing distance from RMC)	Monthly Mean Fluoride Concentration[2] 1987 (parts per million, dry weight)						Seasonal Mean Fluoride Concentration[a] 1978-1987 (parts per million, dry weight)									
	May	June	July	Aug.	Sept.	Oct.	1987[2]	1986[3]	1985[3]	1984[3]	1983[3]	1982[1]	1981[1]	1980[1]	1979[3]	1978[3]
Bridge Site (1.5 NE)* (uncut)	31	39	45	39	31	37	37	26	36	92	52	41	68	52	51	58
N. Point (2.0 NE) (hayfield/grazed)	15	7	23	22	16	13	16	11	15	36	30	25	34	28	20	31
P. Hopps (3.1 NE) (grazed)	10	15	19	16	13	3	13	8	13	25	19	13	35	17	11	17
Dump Site (3.3 NE) (hayfield)	9	5	13	15	14	13	12	7	10	24	15	14	26	16	9	12
E. Benedict (4.1 NE) (grazed)	5	11	13	15	9	6	10	6	10	16	18	12	25	14	12	12
N. Hopps (5.7 NE) (hayfield)	2	4	7	8	10	4	6	6	5	14	13	9	18	7	9	9
P. Caldwell (1.8 NNE) (hayfield)	11	3	17	7	6	19	11	4	7	15	12	13	-	-	-	-
J. Thompson (1.7 N) (grazed)	6	2	14	16	10	15	11	5	8	13	11	10	22	12	10	12

* Approximate distance (km) and direction from RMC.

[a] All 1982 - 1987 results based on Ion Selective Electrode method; Alkali Fusion method used for analysis in 1978 - 1981.

[1] Based on a single sample

[2] Based on duplicate samples

[3] Based on triplicate samples

TABLE 7

Average (June-July-August) Fluoride Results for Unwashed Forage Sampled on Cornwall Island - 1970-1987

Site Location (order of increasing distance from RMC)	*Average Fluoride Concentration (ppm - dry wt.)																	
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982[a]	1983[a]	1984[a]	1985[a]	1986[a]	1987[a]
Bridge Site	597	361	137	128	192	-	-	88**	72	43	43	71	36	48	123	38	26	41
L. Point; N. Point	-	-	66	71	76	116	51	95	37	16	23	29	18	18	53	14	9	17
P. Hopps	-	-	-	-	-	-	32	30	20	9	18	37	10	18	36	12	7	17
Dump Site	-	-	-	-	-	-	-	-	13	6	12	26	9	10	31	7	5	11
E. Benedict	64	79	56	54	29	71	21	23	14	11	13	25	10	17	23	9	6	13
N. Hopps	-	-	-	-	-	-	13	11	9	9	7	21	6	9	19	4	4	6
Customs - Island Road (1977-1981)	-	-	-	-	-	-	-	19**	15	8	11	22						
P. Caldwell - 1982 on	-	-	-	-	-	-	-	-	-	-	-	-	8	7	18	7	3	9
J. Thompson	-	-	11	36	26	72	6	19	8	10	11	15	7	9	15	8	5	11

* 1970-1974; 1980-1982 averages based on a single composite sample collected at each site per month.
1975-1979; 1983-86 averages based on the results of triplicate samples collected monthly at each site. Duplicate samples were collected in 1987.

** Average based on estimated level for June.

[a] 1982-86 results based on Ion Selective Electrode method; in earlier years, the Alkali Fusion method was used.

TABLE 8

Monthly Fluoride Levels Detected in Unwashed Forage Collected on Cornwall Island in May and June 1988 and Corresponding Two Month (May and June) Means for 1978-1988.

Site Location (in order of increasing distance from RMC)	Mean F level (1988)		Average of May and June F Levels - 1978-1988 parts per million, dry weight basis										
	May[b]	June[b]	1988[b]	1987[b]	1986[c]	1985[c]	1984[c]	1983[c]	1982[a]	1981[a]	1980[a]	1979[c]	1978[c]
Bridge Site (1.5 NE)* (uncut)	29	52	41	35	20	46	57	33	10	53	54	24	13
N. Point (2.0 NE) (hayfield/grazed)	9	27	18	11	10	22	22	13	5	21	28	21	10
P. Hopps (3.1 NE) (grazed)	6	31	19	13	7	21	21	19	6	20	23	9	5
Dump Site (3.3 NE) (hayfield)	7	25	16	7	5	15	20	8	5	14	21	8	4
E. Benedict (4.1 NE) (grazed)	5	18	12	8	5	14	12	16	6	20	19	9	4
N. Hopps (5.7 NE) (hayfield)	3	7	5	3	3	5	6	9	3	13	8	5	4
P. Caldwell (1.8 NNE) (hayfield)	13	3	8	7	5	4	10	7	4	14	23	11	4
J. Thompson (1.7 N) (grazed)	9	5	7	4	5	4	8	9	6	8	14	6	4

* Approximate distance (km) and direction from RMC.

[a] Fluoride level in a single sample

[b] Mean of duplicate sample results

[c] Mean of triplicate sample results

TABLE 9

Results of Histological Examination of Foliage Samples Collected from Cornwall Island During 1987 and 1988.

Sampling Date	General Location/ Property	Foliage Type	General Description of Injury	Results of Examination(s)		
				Typical of Fluoride	Some Similarity	Not Typical
			Samples Collected During 1987			
May 14/87	S Shore - E of Bridge	Manitoba Maple	Blackish-grey marginal necrosis			x
		Dogwood	Blackish-brown marginal necrosis		x	
		Staghorn Sumac	Blackish marginal necrosis	x		
	W Bridge Woodlot	Hawthorn	Blackish marginal necrosis			x
June 17/87	E Bridge Woodlot	Red Maple	Blackish marginal necrosis	x		
		Choke Cherry	Reddish marginal necrosis	x		
June 18/87	S Shore - W of Bridge	Trembling Aspen	Blackish marginal necrosis			x
July 13/87	L. Point	Red Maple	Reddish-brown necrosis at tips	x		
		Manitoba Maple	Reddish marginal necrosis in sinus area(s)	x (+moisture stress)		
Aug. 18/87	E Bridge Woodlot	Red Maple	Reddish marginal necrosis	x (+disease)		
	L. Point	Red Maple	Reddish necrosis extending inward from tips			x
Sept. 15/87	N. Point	Red Pine	Reddish tip necrosis on 1987 needles	x		
			Samples Collected During 1988			
May 17/88	S Shore - W of Bridge	Pin Cherry	Reddish necrotic areas at margins			x
		Staghorn Sumac	Blackish necrotic spots along margins			x
June 16/88	W Bridge Woodlot	Choke Cherry	Reddish tip necrosis			x
	E Bridge Woodlot	Choke Cherry	Reddish necrosis at margins	x		

TABLE 10

Concentrations of PCBs and PAHs Detected in Surface Soil (0-5 cm) at the Nine Forage Sites Sampled on Cornwall Island in May, 1988.

Compound	Soil Collection Sites (Order of Increasing Distance (km) from RMC)									Guidelines*
	Bridge Site 1.5 NE	N. Point 2.0 NE	P. Hopps 3.1 NE	Dump Site 3.3 NE	E. Benedict 4.1 NE	N. Hopps 5.7 NE	A. Lazore 6.8 NE	P. Caldwell 1.8 NNE	J. Thompson 1.7 N	
	Concentration (ppm-dry wt. basis)									
PCBs	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.5
PAHs:										
Dibenzo(a,h) anthracene	0.09	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.9
Benzo (g,h,i)perylene	0.50	0.06	0.07	0.05	0.05	<0.04	<0.04	0.05	0.04	n.d
Naphthalene	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	4
Acenaphthylene	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	n.d
Acenaphthene	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	n.d
Fluorene	0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	n.d
Phenanthrene	0.61	<0.07	0.12	<0.07	0.08	<0.07	0.09	<0.07	<0.07	14
Anthracene	0.12	<0.01	0.02	<0.01	0.02	<0.01	0.03	<0.01	<0.01	6
Fluoranthrene	0.99	<0.06	0.16	0.04	0.11	0.08	0.05	0.06	0.04	15
Pyrene	0.74	<0.06	0.11	<0.06	0.09	<0.06	<0.06	<0.06	<0.06	24
Benzo(a)anthracene	0.31	0.04	0.06	0.02	0.05	0.04	0.03	0.03	<0.02	7.9
Chrysene	0.56	0.10	0.17	0.05	0.07	0.05	0.03	0.06	0.04	14
Benzo(k)fluoranthene	0.20	0.02	0.05	0.02	0.02	0.02	0.02	<0.02	<0.02	6.6
Benzo(b)fluorene	0.79	0.28	0.25	0.12	0.13	0.11	<0.06	0.14	0.12	n.d
Benzo(a)pyrene	0.36	0.05	0.07	<0.04	0.05	0.05	<0.04	<0.04	<0.04	1.2
Indeno(1,2,3-c,d)pyrene	0.48	0.06	0.08	0.05	0.06	<0.04	<0.04	0.05	0.04	n.d

* PCB guideline for agricultural soil, including home gardens, was developed by a joint Federal/Provincial Working Group; PAH soil guidelines for residential land use were recommended by an Inter-Ministry Committee on Clean-up Criteria.

n.d. = No guideline developed.

TABLE 11

Percentage of Time Winds Were from the S, SW and W, and
Total Precipitation and Number of Days With Rain Recorded at
The Ontario Hydro Climatic Station, Cornwall - May through August 1978-1987

Year	MAY					JUNE					JULY					AUGUST					MAY-AUGUST*					
	% Wind			Rain (mm)		% Wind			Rain (mm)		% Wind			Rain (mm)		% Wind			Rain (mm)		% Wind			Rain (mm)		
	S	SW	W	Tot.	Freq.	S	SW	W	Tot.	Freq.	S	SW	W	Tot.	Freq.	S	SW	W	Tot.	Freq.	S	SW	W	Tot.	Freq.	
1978	6	19	31	79	10	6	23	28	71	17	5	32	28	51	9	6	27	25	102	11	6	25	28	303	47	(8)
1979	7	18	19	64	14	6	28	27	41	10	4	27	31	48	10	7	29	24	130	16	6^{a}	26^{a}	25^{a}	283^{a}	50^{a}	
1980	6	19	23	39	7	3	17	33	38	12	5	25	33	114	19	5	21	22	137	13	5	21	28	292	49	(5)
1981	6	15	24	109	15	7	23	34	95	14	4	17	31	69	8	10	15	28	122	16	6	18	30	382	50	(5)
1982	9	11	19	58	8	5	23	20	86	14	2	24	34	66	10	3	23	33	125	12	5	20	26	324	42	(8)
1983	7	18	24	88	17	4	26	43	79	11	2	28	25	92	11	6	23	29	61	8	5	24	30	317	46	(4)
1984	3	17	39	113	18	4	22	38	55	8	2	26	48	51	11	2	23	34	95	14	3	21	40	296	47	(7)
1985	5	18	21	68	12	5	19	29	148	18	3	32	38	68	11	3	24	23	70	9	4	24	28	336	48	(6)
1986	6	13	20	90	18	2	18	31	108	13	2	13	32	165	14	7	24	29	104	16	4	17	28	466	60	(7)
1987	7	16	29	64	18	4	21	33	82	18	5	23	30	111	15	6	20	18	98	15	6	20	28	314	57	(6)
Norms**	-			70	12	-			70	11	-			76	11	-			99	11	-			-		

* May through to and including date of regular maple foliage collection near end of August: 1978 - Aug. 29; 1979^{a} - Sept. 5; 1980 - Aug. 27; 1981 - Aug. 26; 1982 - Aug. 25; 1983 - Aug. 23; 1984 - Aug. 23; 1985 - Aug. 28; 1986 - Aug. 27; 1987 - Aug. 18
(a - 1979 May - August* values represent the period May - August 31)

** Rainfall normals taken from Canadian Climate Normals, Atmospheric Environment Service, Environment Canada, Toronto

( ) Number of days with rain during the two-week period prior to maple collection

Figure 1: Manitoba Maple Foliage and Forage Sites Sampled in the RMC Survey Area - 1986-1988

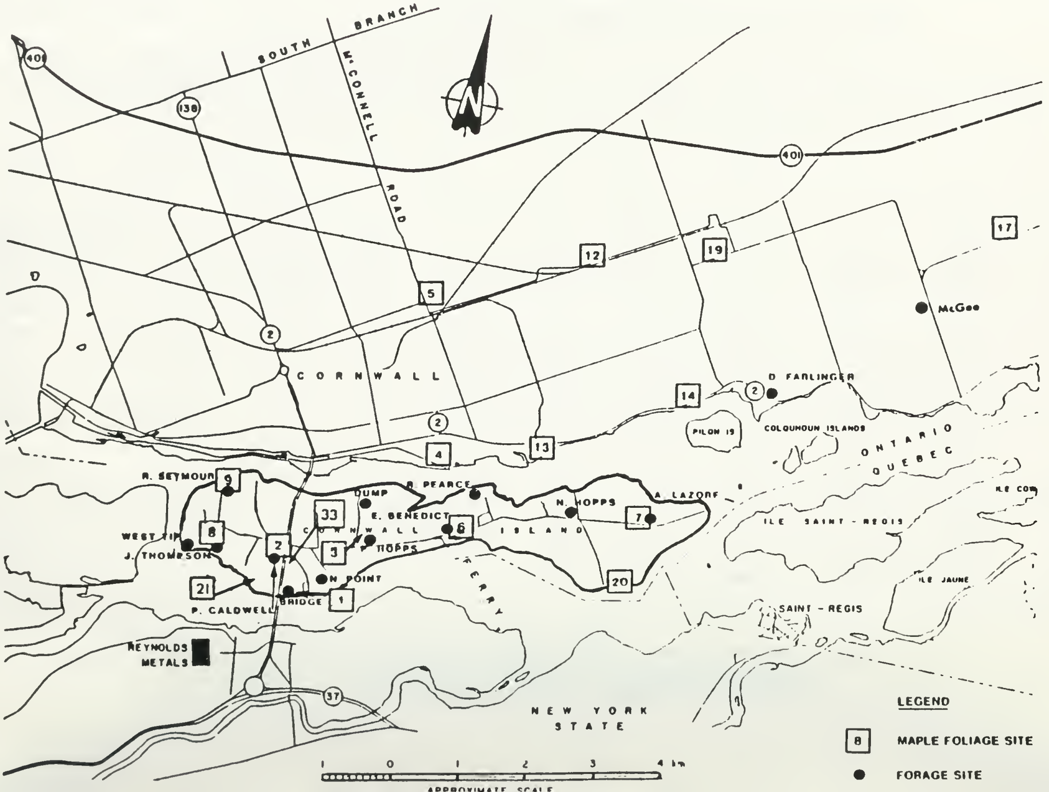

Figure 2: Other Property Locations Cited in Recent Years' (1985-1988) Reports.